Effects of Mobilization-with-Movement on Pain and Range of Motion in Patients with Unilateral Shoulder Impingement Syndrome: A Randomized Controlled Trial

Authors

José A Delgado-Gil [1], Eva Prado-Robles [2], Daiana P Rodrigues-de-Souza [3], Joshua A Cleland [4], César Fernández-de-las-Peñas [5], Francisco Alburquerque-Sendín [6]

Affiliations

1. Physical Therapist, Primary Care Service Area, León, Spain.

2. Occupational Therapist, General Hospital, León, Spain.

3. Physical Therapist, Department of Psychology, Social and Anthropology, University of Salamanca, Salamanca, Spain.

4. Professor, Department of Physical Therapy, Franklin Pierce University, Manchester, NH.

5. Professor, Department of Physical Therapy, Occupational Therapy, Physical Medicine and Rehabilitation, University Rey Juan Carlos, Alcorcón (Madrid), Spain.

6. Professor, Department of Nursing and Physical Therapy, University of Salamanca, Salamanca, Spain.

ABSTRACT

Objectives: To compare the immediate effects of Mobilization-with-Movement (MWM) to a sham technique in patients with shoulder impingement syndrome.

Methods: A randomized controlled trial was performed. Forty-two patients (mean ± SD age: 55±9 years; 81% female) satisfied eligibility criteria, agreed to participate, and were randomized into MWM group (n=21) or sham manual contact (n=21). The primary outcome measures including pain intensity, pain during active range of motion, and maximal active range of motion were assessed by a clinician blinded to group allocation. Outcomes were captured at baseline and after 2 weeks of MWM treatment or sham intervention. The primary analysis was the Group * Time interaction.

Results: The 2x2 ANOVA revealed a significant Group * Time interaction for pain intensity during shoulder flexion ($F=7.054$, $P=0.011$), pain-free shoulder flexion ($F=32.853$; $P<0.001$), maximum shoulder flexion ($F=18.791$; $P<0.01$), and shoulder external rotation ($F=7.950$; $P<0.01$) in favor of the MWM group. No other significant differences were found.

Conclusions: The results of the current randomized clinical trial demonstrated that patients with SIS who received 4 sessions of MWM exhibited significantly better outcomes for pain during shoulder flexion, pain-free range of shoulder flexion, maximal shoulder flexion and maximal external rotation than those patients who were in the sham group. Future studies should examine the long-term effects of these interventions in patients with SIS.

Key words: shoulder impingement syndrome, musculoskeletal manipulations, pain, range of motion.

Introduction

Shoulder problems are a significant societal and economic burden as they are one of the most common musculoskeletal disorders.[1] In fact, it has been reported that the prevalence of shoulder pain is between 2.4 and 4.8% in the general population.[2,3] A considerable portion of individuals with shoulder complaints continue to experience pain at long-term follow-up periods.[4] Furthermore, it has been identified that the most common shoulder condition that individuals with shoulder pain present with is shoulder impingement syndrome (SIS).[5]

The first treatment options for SIS are anti-inflammatory medications and physical therapy.[1] Physical therapy interventions usually include exercises and manual therapy. A number of studies have shown manual therapy to be effective in the management of individuals with shoulder pain.[6,7,8] However, a systematic review found that there was no consistent evidence to support the use of manual therapy for individuals with shoulder pain.[9] That systematic review concluded that one specific type of manual therapy, Mobilization-with-Movement was beneficial at short-term when compared to sham control; however, futher studies are required.[9]

Mobilization-with-Movement entails having a clinician apply an accessory mobilization to a joint while the patient actively performs a physiological movement.[10] The clinician monitors the patient's status during the mobilization and if the patient begins to experience pain, the technique is ceased.[10] Patients with SIS exhibit abnormal movement of the humeral head in the direction of superior or anterior translation during active movements.[11,12] Therefore, it was hypothesized that a posterior glide of the humerus during active shoulder movements may assist in correcting these faulty mechanics.[10]

To date only a few studies have examined the effect of Mobilization-with-Movement (MWM) in patients with shoulder pain. The first one indicated that range of motion in the plane of the scapula and pain pressure thresholds changed immediately after the treatment.[1,3] The second demonstrated that the addition of shoulder taping combined with MWM resulted in

better improvements in range of motion than MWM alone.[14] However, the aforementioned 2 studies where crossover designs, and not randomized controlled parallel studies. A pilot randomized clinical trial 33 patients with SIS to 1 of 4 groups, a mobilization group, MWM group, exercise group, and control.[15] The results demonstrated that there were no differences between any of the groups in terms of range of motion or function. However, the study was underpowered, because it included 33 patients randomly assigned into 4 groups, to determine if an actual difference truly existed due to the small sample size of each group.[15]

Therefore, the purpose of the current study was to perform a randomized controlled trial comparing the effects of MWM to a group receiving a sham intervention on shoulder pain during active movement and active shoulder range of motion in an adequately powered sample of patients with SIS.

Methods

Design

A repeated measure, double blind randomized, controlled trial was conducted (registered with ClinicalTrials.gov, NCT02172079) following the CONSORT guidelines. The absence of previous experience with manual therapy applied to the shoulder of all participants (naïve) assisted with patient blinding. Patients were informed that the current study investigated the effects of manual handling on shoulder pain, without any information of the real objective of testing specific technique effects.

Participants

Patients with unilateral shoulder pain compatible with medical diagnosis of shoulder impingement syndrome were screened for eligibility criteria from January 2013 to January 2014. Patients were included if they had: 1, history of shoulder pain of > 3months duration; 2, pain localized at the proximal anterolateral shoulder region; 3, medical diagnosis of SIS with at least 2 positive impingement tests including Neer, Hawkins, or Jobe test.[16-18] Hegedus et al

revealed that the pooled sensitivity and specificity for the Neer test was 79% and 53%, respectively, and for the Hawkins test was 79% and 59%, respectively.[19] Since no single test had shown high specificity; a cluster of 2 or more tests is recommended to properly identify patients with SIS.[20]

Exclusion criteria included: 1, diagnosis of fibromyalgia; 2, pregnancy; 3, a history of traumatic onset of shoulder pain; 4, other histories of shoulder injury; 5, torn tendons; 6, ligamentous laxity based on a positive Sulcus test and apprehension test; 7, numbness or tingling in the upper extremity; 8, previous shoulder or cervical spine surgery; 9, systemic illness; 10, corticosteroid injection on the shoulder within 1 year of the study; 11, physical therapy 6 months prior to the study.

This project was approved by the Ethics Committee of the Universidad of Salamanca (USAL 201000048540). Patients provided written and informed consent to participate in this study, which was conducted according to the Helsinki Declaration.

Interventions

For the MWM group, an accessory posterior-lateral gliding movement in the humeral head combined with a movement of active shoulder flexion[21] was performed by a physical therapist with more than 10 years of experience in manual therapy. The patient was sitting with the therapist on the opposite side of the shoulder. One hand was placed over the scapula posteriorly while the thenar eminence of the other hand was placed over the anterior aspect of the head of the humerus (**Fig. 1**). The best combination of manual pressure and plane of motion was evaluated through manual palpation to perform the painless active shoulder flexion. The therapist maintained the manual glide on the humeral head during all pain-free movements, avoiding pressure on the sensitive areas (i.e. coracoid process, **Fig. 2**). The technique was first explained to the participant prior to its application, including it must be pain-free and the technique would cease if any painful symptom was experienced during the application. Three

sets of ten repetitions with a rest interval of 30 seconds between sets were applied at each treatment session.

The sham condition replicated the treatment condition except for the hand positioning. The therapist located one hand over the belly of the pectoralis major muscle and the other over scapula without applying any pressure (**Fig. 3**). The patient was also asked to move the arm in a similar manner as in the MWM group (**Fig. 4**). The number of repetitions and sets were the same as for the treatment group. Each intervention (MWM or sham) was applied 4 days over two weeks (2 treatment sessions per week). The approximate length of each treatment session was 10 minutes.

Pain intensity

Participants were asked to rate the intensity of their pain using an 11-point numerical pain rating scale (NPRS; 0: no pain; 10: maximum pain).[22] Patients were asked for 3 scores of perceived pain: 1, the intensity of shoulder pain experienced in the last 24h; 2, the intensity of shoulder pain at night; 3, the intensity of shoulder pain during shoulder flexion. Mintken et al reported that the NPRS showed high test-retest reliability (ICC: 0.74) and a minimal clinically important difference (MCID) of 1.1 points in patients with shoulder pain.[23]

Shoulder range of motion

A universal goniometer was used to assess the participant's shoulder range of motion. All measures were conducted following international guidelines.[24] The universal goniometer exhibited to have good intrarrater reliability (ICC ranging from 0.91 to 0.99) if consistent landmarks are used,[25] and it is as valid as an inclinometer.[26] In general, it is accepted that a change of 6-11º is needed to be certain that true change has occurred with goniometric measurements of the shoulder.[25,27]

Pain-free and maximum (painful) range of motion in shoulder flexion: The center of the goniometer was aligned with the center of axis of the shoulder joint posteriorly; one arm of the goniometer was aligned

with the humerus. These points were marked with a permanent pencil. To ensure that shoulder flexion was conducted in the plane of the scapula, one arm of the goniometer was placed along the superior border of the scapula, whereas the other arm of the goniometer was moved forward 30º from the coronal plane. A vertical line was marked on the wall to align with this procedure. The participant was asked to elevate their upper extremity following the vertical line on the wall, with the thumb pointed upward. This outcome was assessed twice, first the patient was asked to move forward until the first sensation of discomfort appears (pain-free); and secondly, they moved forward until the maximum possible end-range of motion (painful).

Pain-free range of motion in shoulder extension: The patient was in the prone position with the shoulder in neutral; the forearm flexed 90º, and the wrist in a neutral position. The center of the goniometer was placed at the midpoint of the lateral aspect of the glenohumeral joint; one arm was placed parallel to the trunk of the patient, and the other arm was placed parallel to the longitudinal axis of the humerus. The upper extremity was actively elevated in the sagital plane for extension.

Pain-free range of motion in shoulder abduction: The patient was seated on a chair with the trunk upright. The center of the goniometer axis was placed at the midpoint of the posterior aspect of the glenohumeral joint; one arm was placed parallel to the trunk; and the other arm was placed parallel to the longitudinal axis of the humerus. The upper extremity was actively elevated in the coronal plane in abduction with the thumb pointed up toward the ceiling to allow the required external rotation necessary to avoid impingement of the greater tuberosity on the acromion process.

Pain-free range of motion in shoulder external rotation: The patient was in supine with the hips and knees flexed approximately 45º. The tested arm was supported on the table in 90º of abduction; elbow flexed 90º, and the wrist in neutral position. A towel roll was placed under the humerus to ensure neutral horizontal positioning. The center of the goniometer was placed on the olecranon; one arm was placed parallel to the floor and the other arm was parallel with

the forearm. Once positioned, participants were asked to rotate the upper extremity back into external rotation to their end available pain-free range of motion.

Pain-free range of motion in shoulder medial (internal) rotation: The patient was in prone with the tested extremity supported on the table in 90º of abduction; the forearm flexed 90º, and the wrist in neutral. A towel roll was placed directly under the arm to ensure neutral horizontal positioning and to provide stabilization. The center of the goniometer was placed on the olecranon; one arm was parallel to the floor and the other arm was parallel to the forearm. The participant was instructed to internally rotate the arm while maintaining the 90º abducted position. The tester carefully monitored participants to avoid compensatory scapular movement.

Three measurements of each movement were recorded and the average calculated for further data analyses. For each active repetition, participants were requested to move their arm to end-range and maintain the position while the angle was recorded. Once the measurement was recorded, participants returned their arm to a neutral zero-degree position and the next measurement was then repeated.

Study protocol

The eligible participants were first contacted by telephone, and those who agreed to participate were scheduled for the initial evaluation. Upon arrival, the subjects received a complete explanation of the study protocol by a therapist with more than 10 years of clinical experience who performed all screening examinations. The main outcome of the study was pain intensity during shoulder movements, whereas the secondary outcome was active shoulder range of motion. Following the baseline examination, patients were randomly assigned to receive either real Mobilization-with-Movement (MWM) intervention or sham manual contact (control group). The interventions (MWM or sham) were applied 4 days over two weeks (2 sessions per week). The approximate length of each treatment session was 10 minutes.

Concealed allocation was performed using a computer-generated randomized table of numbers created prior to start of data collection by a researcher not involved in the recruitment and/or treatment of the patients. Individual and sequentially numbered index cards with the random assignment were prepared. The index cards were folded and placed in sealed opaque envelopes. A second therapist, blinded to baseline examination findings, opened the envelope and proceeded with treatment according to the group assignment. Outcomes were taken by an assessor blinded to group allocation at baseline and 24h post-intervention (after 4 treatments over a 2-week timeframe). Participants were asked to avoid any analgesic or muscle relaxant medications 72 hours prior to the examination.

Sample Size Determination

The sample size was calculated using Ene 3.0 software (GlaxoSmithKline, Autonomic University of Barcelona, Spain). The calculations were based on detecting differences of 1.1 units in an 11-point NPRS at post-data (MCID), assuming a standard deviation of 1.1,[23] a 2-tailed test, an alpha level (α) of 0.05, and a desired power (β) of 80%. The estimated desired sample size was calculated to be at least 17 participants per group. The sample was increased to 21 to allow for 20% drop out.

Statistical Analyses

Statistical analysis was performed using SPSS statistical software, version 18.0. Mean, standard deviations and/or 95% confidence intervals were calculated. The Kolmogorov-Smirnov test showed a normal distribution of all quantitative data ($P>0.05$). Baseline demographic and clinical variables were compared between both groups using independent Student t-tests for continuous data and $\chi 2$ tests of independence for categorical data. A 2x2 repeated measured analysis of variance (ANOVA) with time (baseline and 1week after the 4th

treatment) as the within-subjects factor and group (MWM, sham) as the between-subjects factor was used to determine the effects of the intervention on pain and shoulder range of motion. Independent ANOVAs were used for each outcome. The main hypothesis of interest was the Group * Time interaction. To enable comparison of effect sizes, standardized mean score differences (SMD) were calculated by dividing mean score differences between MWM and sham placebo group by the pooled standard deviation. The statistical analysis was conducted at 95% confidence level, and a P value < 0.05 was considered statistically significant.

Results

Eighty-seven (n=87) consecutive patients with shoulder pain were screened for eligibility criteria. Forty-two patients (mean ± SD age: 55 ± 9 years; 81% female) satisfied the eligibility criteria, agreed to participate, and were randomized into MWM group (n=21) or sham manual contact (n=21). The reasons for ineligibility are found in **Figure 5**, which provides a flow diagram of patient recruitment and retention. Demographics and baseline data were similar for all variables between groups (**Table 1**).

The 2x2 ANOVA revealed a significant Group * Time interaction for the intensity of shoulder pain during shoulder flexion (F=7.054, P=0.011), but not for intensity of shoulder pain experienced in the last 24h (F=1.944; P=0.171) or the intensity of shoulder pain at night (F=1.970; P=0.191): patients receiving MWM experienced greater decrease in shoulder pain during shoulder flexion than those receiving sham manual contact. Between-groups effect size was large (SMD: 0.9) in favour of the MWM group. In addition, there was a main effect for time with both groups experiencing similar decreases in shoulder pain at night (F=11.301; P=0.002) with moderates within-group effect sizes (0.64>SMD>0.27). **Table 2** provides baseline and after intervention data as well as within-group and between-groups differences with their associated SMD for shoulder pain intensities.

The mixed model ANOVA revealed a significant Group * Time interaction for pain-free shoulder flexion (F=32.853; P<0.001), maximum shoulder flexion (F=18.791; P<0.01); and shoulder external rotation (F=7.950; P<0.01), but not for shoulder extension (F=0.398; P=0.532), shoulder medial rotation (F=2.504; P=0.121) and shoulder abduction (F=0.052; P=0.821): patients receiving MWM experienced greater increases in pain-free and maximum shoulder flexion and shoulder external rotation than those receiving sham manual contact. Between-groups effect sizes were large (1.8>SMD>0.9) in favour of the MWM group. Again, there was a main effect for time with both groups experiencing similar increases in shoulder abduction (F=4.247; P=0.046), but with small within-group effect sizes (SMD<0.26). **Table 2** provides baseline and after intervention data as well as within-group and between-groups differences with their associated SMD for shoulder pain and shoulder range of motion.

Discussion

The results of this randomized controlled trial demonstrated that patients receiving real MWM experienced significantly greater reductions in the intensity of pain during shoulder flexion, the amount of pain-free shoulder flexion, the maximal shoulder external rotation and maximal shoulder flexion than those patients receiving the sham intervention. It should be recognized that the difference between groups for the change in intensity of pain during shoulder flexion was 1.4 points which exceeds the MCID reported by Mintken et al.[23] However, the lower bound estimate of the 95% CI does not exceed the MCID which does allow us to say with certainty that a true difference between groups exists for all patients.

Pain-free shoulder flexion and maximal flexion in the MWM group exceeded that of the control group by 34.2º and 19.3º respectively which exceeds the MCID for goniometric measurements of the shoulder as previously reported.[25,27] Additionally, the lower bound estimate of the 95% CI also surpassed these values. This was not found to be the case for external rotation. It is interesting to note that the only two identified differences between groups

that provides convincing evidence that MWM provides clinical advantages over a sham MWM technique was in the direction of shoulder flexion. Perhaps the reason for the improvements in flexion is directly related to the fact that the treating clinician applied a posterior-lateral gliding movement to the humeral head combined with a movement of active shoulder flexion. It is plausible that if we had chosen to perform the technique during a different motion that we could have also seen differences in other measures.

Our results are similar to those reported by Teys et al[13] that demonstrated MWM resulted in significant differences in shoulder flexion as compared to a sham. However, the increase in range of motion was about half of what was identified in the current study. This may be related to the fact that Teys et al only provided 1 treatment session while in the current study each patient received 4 sessions of MWM. Conversely, in a pilot clinical trial[15] there were no differences in improvements in shoulder flexion range of motion between a mobilization group, an exercise group, or a control. However, the sample size was small and the study was underpowered so it is difficult to make comparisons to the current trial.

The potential reasons as to why patients in the MWM group improved are speculative at this time. However, it has been shown that patients with shoulder impingement syndrome typically have a tight posterior glenohumeral joint capsule which in turn may cause abnormal gleno-humeral mechanics resulting in compression of the structures that pass through the sub-acromial space.[28] Possibly the posterior-lateral force applied by the clinician diminished the abnormal translation of the humerus which has been identified in individuals with shoulder problems.[29] It is possible that the posterior-lateral glide performed during shoulder elevation may improve capsular extensibility resulting in improved shoulder mechanics resulting in a reduction of the impingement during flexion.[30] It is also possible that changes in pain, motor control system, or muscle tissues may have contributed to the improvements experienced in the MWM group.[31]

In the current study, MWM was the sole intervention. In typical physical therapy practice a multimodal treatment approach is often used. It is possible that combining MWM with other commonly used interventions including exercise and taping may result in greater improvements. For example, Tyes et al[14] compared one session of MWM alone to MWM combined with a taping technique. Patients were followed-up immediately post-intervention, 30min post-intervention, 1 day, and 1week after. Results demonstrated that the group that received taping in addition to MWM experienced significantly (and in most cases clinically meaningful) improvements in shoulder flexion immediately post intervention, at 1day and 1week follow-up periods. Future studies should examine the effects of combinations of different therapeutic interventions.

Finally, there are a number of limitations that should be considered when interpreting the results of the current randomized clinical trial. First, only one clinician provided all of the MWM treatments which limit the generalizability of the results. Second, we did not capture a measure of function and only included a short-term follow-up. Third, we only applied MWM intervention in isolation when in reality physical therapists usually treat using a multi-modal approach for the management of shoulder impingement, so this doesn't truly reflect actual clinical practice. Lastly, our treatment interventions were only applied over 4 sessions over a 2weeks period due to practical reasons and based on the authors' clinical experience since no available data exist in relation to MWM technique dose. We do not know if a greater number of sessions will reveal greater changes in outcomes or differences between the interventions. Future studies should include numerous treating clinicians, multimodal therapeutic approach, include a functional outcome measure and include a long-term follow-up.

Conclusions

The results of the current randomized clinical trial demonstrated that individuals with shoulder impingement syndrome who received 4 sessions of MWM exhibited significantly

better outcomes for pain during shoulder flexion, pain-free range of shoulder flexion motion, maximal shoulder flexion and maximal external rotation than patients who were received the sham treatment. Furthermore, the differences between groups for pain-free shoulder flexion and maximal shoulder flexion exceeded the MCID as did their lower bound estimates of the 95% CI.

References

1. Paloneva J, Koshela S, Kautiainen H, Vanhala M, Kiviranta I. Consumption of medical resources and outcome of shoulder disorders in primary health care consulters. BMC Musculoskeletal Dis 2013; 14: 348.
2. Linsell L, Dawson J, Zondervan K, Rose P, Randall T, Fitzpatrick R et al. Prevalence and incidence of adults consulting for shoulder conditions in UK primary care; patterns of diagnosis and referral. Rheumatology 2006; 45: 215-21.
3. Greving K, Dorrestijn O, Winters JC, Groenhof F, van der Meer K, Stevens M et al. Incidence, prevalence and consultation rates of shoulder complaints in general practice. Scand J Rheumatol 2012; 41: 150-5.
4. Kuijpers T, van der Windt DA, van der Heijden GJ, Bouter LM: Systematic review of prognostic cohort studies on shoulder disorders. Pain 2004; 109: 420-31.
5. Millar AL, Jasheway PA, Eaton W, Chris¬tensen F. A retrospective, descriptive study of shoulder outcomes in outpatient physical therapy J Orthop Sports Phys Ther 2006; 36: 403-14.
6. Bang MD, Deyle GD. Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. J Orthop Sports Phys Ther 2000; 30: 126-37.
7. Kachingwe AF, Phillips B, Sletten E, Plunkett SW. Comparison of manual therapy techniques with therapeutic exercise in the treatment of shoulder impingement: a randomized controlled pilot clinical trial. J Man Manip Ther 2008; 16: 238-47.
8. Bergman GJ, Winters JC, Groenier KH, Pool JJ, Meyboom-de Jong B, Postema K, et al. Manipulative therapy in addition to usual medical care for patients with shoulder dysfunction and pain: a randomized, controlled trial. Ann Intern Med 2004; 141: 432-9.
9. Ho C, Sole G, Munn J The effectiveness of therapy in the management of musculoskeletal disorders of the shoulder: a systematic review. Man Ther 2009; 14: 463-74.

10. Mulligan BM. Manual therapy: "NAGS", "SNAGS", "MWMS", etc. (3rd edition). Wellington: Plane View Services; 2003.

11. Flatow E, Soslowsky J, Ticker J, Pawluk R, Hepler M, Ark J et al. Excursion of the rotator cuff under the acromion. Patterns of subacromial contact. Am J Sports Med 1994; 22: 7779-88.

12. Kamkar A, Irrgang J. Nonoperative management of secondary shoulder impingement syndrome. J Orthop Sports Phys Ther 1993; 17: 212-24.

13. Teys P, Bisset L, Vicenzino B. The initial effects of a Mulligan's mobilization with movement technique on range of movement and pressure pain threshold in pain-limited shoulders. Man Ther 2008; 13: 37-42.

14. Teys P, Bisset L, Collins N, Coombes B, Vicenzino B. ne-week time course of the effects of Mulligan's Mobilisation with Movement and taping in painful shoulders. Man Ther. 2013; 18: 372-7.

15. Kachingwe AF, Phillips B, Sletten E, Plunkett SW. Comparison of manual therapy techniques with therapeutic exercise in the treatment of shoulder impingement: a randomized controlled pilot clinical trial. J Man Manip Ther 2008; 16: 238-47.

16. Neer CS. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. J Bone Joint Surg 1972; 54: 41-50.

17. Hawkins RJ, Kennedy JC. Impingement syndrome in athletes. Am J Sports Med 1980; 8: 151-58.

18. Jobe FW, Moynes DR. Delineation of diagnostic criteria and a rehabilitation program for rotator cuff injuries. Am J Sports Med 1982; 10: 336-39.

19. Hegedus EJ, Goode A, Campbell S, Morin A, Tamaddoni M, Moorman CT 3rd et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. Br J Sports Med 2008; 42: 80-92.

20. Michener LA, Walsworth MK, Doukas WC, Murphy KP. Reliability and diagnostic accuracy of 5 physical examination tests and combination of tests for sub-acromial impingement. Arch Phys Med Rehabil 2009; 90: 1898-903.

21. Mulligan B. The painful dysfunctional shoulder: a new treatment approach using 'mobilisation-with-movement'. New Zealand J Physiother 2003; 31: 140.

22. Jensen MP, Turner JA, Romano JM, Fisher LD. Comparative reliability and validity of chronic pain intensity measures. Pain 1999; 83: 157-62.

23. Mintken PE, Glynn P, Cleland JA. Psychometric properties of the shortened disabilities of the Arm, Shoulder, and Hand Questionnaire (QuickDASH) and Numeric Pain Rating Scale in patients with shoulder pain. J Shoulder Elbow Surg 2009; 18: 920-6.

24. Norkin CC, White DJ. Measurement of joint Motion: A Guide to Goniometry (3rd edition). Philadelphia, PA: F. A. Davis, 2003.

25. Mullaney M, McHugh M, Johnson C, Tyler T. Reliability of shoulder range of motion comparing a goniometer to a digital level. Physiother Theory Practice 2010; 26: 327-33.

26. Kolber MJ, Hanney WJ. The reliability and concurrent validity of shoulder mobility measurements using a digital inclinometer and goniometer: a technical report. Int J Sports Phys Ther 2012; 7: 306-13.

27. Kolber MJ, Vega F, Widmayer K, Cheng MS. The reliability and minimal detectable change of shoulder mobility measurements using a digital inclinometer. Physiother Theory Pract 2011; 27: 176-84.

28. Grossman MG, Tibone JE, McGarry MH, Schneider DJ, Veneziani S, Lee TQ. A cadaveric model of the throwing shoulder: A possible etiology of superior labrum anterior-to-posterior lesions. J Bone Joint Surg Am 2005; 87: 824-31.

29. Ludewig PM, Cook TA. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Phys Ther 2000; 80: 276-91.

30. Conroy DE, Hayes KW. The effect of joint mobilization as a component of comprehensive treatment for primary shoulder impingement syndrome. J Orthop Sports Phys Ther 1998; 28: 3–14

31. Wright A. Hypoalgesia post manipulative therapy: a review of potential neurophysiological mechanism. Man Ther 1995; 1: 11–6.

Legend of figures

Figure 1: Hand positioning for real Mobilization-with-Movement (MWM) intervention. One hand is placed over the scapula posteriorly while the thenar eminence of the other hand is placed over the anterior aspect of the head of the humerus.

Figure 2: Real Mobilization-with-Movement (MWM) intervention. The therapist maintains a posterior-lateral manual glide on the humeral head at the same time that the patient is asked to move the shoulder in flexion.

Figure 3: Hand positioning for sham intervention. One hand is placed over the belly of the pectoralis major muscle and the other over scapula without applying any pressure.

Figure 4: Sham intervention. The patient is asked to move the arm in a similar manner as in the MWM group with the sham-hand positioning.

Figure 5: Flow diagram of patients throughout the course of the study.

TABLES

Table 1: Baseline demographics for Both Groups

Clinical features	MWM group (n=21)	Sham group (n=21)
Gender (male/female)	4/17	4/17
Age (y)	55.4 ± 7.8	54.3 ± 10
Pain duration (mo)	9.2 ± 6.7	11.7 ± 7.9
Dominance (right/left)	20/1	21/0
Dominant side involved (%)	14 (66.7)	13 (61.9)

MWM: Mobilization-with-Movement

Values are expressed as mean ± standard deviation, except where otherwise indicated. There were no significant differences between groups (P>0.05).

Table 2: Baseline, final values, change scores, and effect sizes for shoulder pain and range of motion outcomes

Outcome Group	Baseline	End of Treatment	Within-Group Changes	Within-Group Effect Sizes	Between-Group Differences in Change Scores	Between-Group Effect Sizes
Shoulder Pain 24h (0-10)						
Sham	6.6 ± 2.1	6.8 ± 1.7	0.2 (-0.5, 1.1)	-0.13	-0.8 (-2.0, 0.4)	0.4
MWM	6.5 ± 1.6	5.9 ± 2.3	-0.6 (-1.4, 0.2)	0.29		
Shoulder pain at night (0-10)						
Sham	6.7 ± 2.3	6.0 ± 2.9	-0.7 (-1.7, 0.3)	0.27	-1.0 (-2.4, 0.4)	0.4
MWM	6.4 ± 2.3	4.7 ± 3.1	-1.7 (-2.8, -0.7)	0.64		
Pain with shoulder flexion (0-10)						
Sham	6.8 ± 1.6	7.1 ± 4.5	0.3 (-0.4, 0.9)	-0.17	-1.4 (-2.8, -0.4)	0.9
MWM	6.2 ± 1.9	5.1 ± 2.2	-1.1 (-1.7, -0.3)	0.50		
Pain-free Shoulder Flexion (º)						
Sham	120.6 ± 23.3	117.3 ± 20.5	-3.2 (-11.8, 5.3)	-0.15	34.2 (43.4, 25.0)	1.8
MWM	103.7 ± 29.5	134.6 ± 20.8	31.0 (22.4, 39.5)	1.23		
Maximum Shoulder Flexion (º)						
Sham	141.6 ± 20.7	142.5 ± 20.4	0.9 (-5.5, 7.2)	0.04	19.3 (27.9, 10.7)	1.4
MWM	133.6 ± 25.7	153.7 ± 15.6	20.1 (13.8, 26.5)	0.97		
Shoulder Extension (º)						
Sham	28.9 ± 12.1	28.9 ± 10.2	0.0 (-3.0, 2.9)	0.00	1.3 (-2.8, 5.3)	0.2
MWM	27.1 ± 8.1	28.3 ± 6.8	1.2 (-1.7, 4.1)	0.17		
Shoulder Abduction (º)						
Sham	89.3 ± 26.2	95.0 ± 25.9	5.8 (-3.2, 14.7)	0.22	1.4 (-9.6, 12.4)	0.1
MWM	98.6 ± 24.5	105.8 ± 29.7	7.2 (-1.8, 16.2)	0.26		
Shoulder External rotation (º)						
Sham	55.7 ± 14.9	54.3 ± 16.5	-1.4 (-5.5. 2.8)	-0.09	8.2 (14.6, 1.8)	0.9
MWM	46.1 ± 18.6	62.9 ± 19	6.8 (2.7, 11.0)	0.36		
Shoulder Medial rotation (º)						
Sham	61.6 ± 19.3	61.8 ± 15.9	0.2 (-5.4, 5.7)	0.01	6.1 (-2.0, 14.3)	0.5
MWM	59.5 ± 16.6	65.8 ± 18.2	6.3 (0.8, 11.9)	0.36		

VAS: Visual Analogue Scale; MWM: Mobilization-With-Movement.

Values are expressed as mean ± standard deviation for baseline and final means and as mean (95% confidence interval) for within-group and between-group change scores (higher values indicate greater movement and lower levels of pain).